



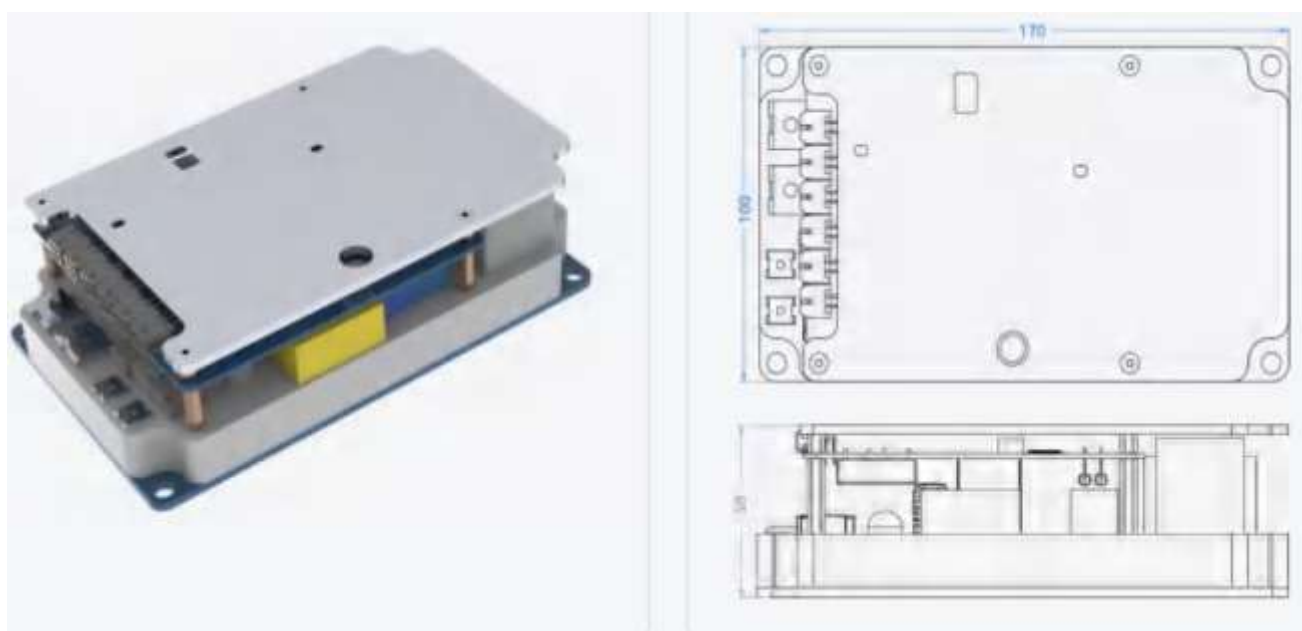
Non-Isolated Step-Down Fast Charging DC/DC CONVERTER

Model No. ATRFD7K-300S96M

Specification & Integration Guide

Pre-charge, Contactors, Insulation Monitoring and Fault Protection

Application: 96 V / 108 V Battery Platform with V2V or CCS2 DC Charging Source



Model No.	ATRFD7K-300S96M
Part Name	7 kW non-isolated buck DC/DC charging module
Input	200-750 VDC (rated 300 VDC)
Output	0-200 VDC, 0-80 A
Target system	High-voltage DC source to nominal 96 V / 108 V traction battery
Document status	Conceptual reference design; not a released production schematic

Important: This document translates and consolidates the proposed integration approach. Final component selection, safety thresholds, wiring, software state machines and certification must be validated using the supplier's complete electrical data, system-level DFMEA, safety analysis and the requirements of the target vehicle market.

Prepared for technical and commercial discussion



Executive Summary

The ATRFD7K-300S96M can be used as the power-conversion stage in a system that accepts a 200-750 VDC charging source and charges a nominal 96 V or 108 V battery. It is not, by itself, a complete V2V or CCS2 charging system. The surrounding system must provide high-voltage switching, pre-charge, insulation monitoring, connector interlocks, communications, independent protection and safe shutdown.

Because the module is non-isolated, the input and output become part of the same galvanically connected high-voltage domain whenever the converter is enabled. The insulation concept must therefore be designed for the highest possible source voltage, up to the module's 750 VDC input rating, rather than only for the nominal 96 V or 108 V battery.

Recommended baseline: Recommended baseline: dual-pole input and output contactors, output pre-charge, an insulation-monitoring device covering the complete high-voltage domain, independent voltage/current sensing, HVIL, suitable DC fuses, EVCC/PLC for CCS2, and a dedicated Safety ECU coordinating the EVCC, BMS, ATRFD7K-300S96M and contactors.

1. Purpose and Design Basis

This guide provides a reference architecture for integrating the ATRFD7K-300S96M into a 7 kW charging system with the following intended operating conditions:

- High-voltage DC source: nominally 200-400 VDC for the current CCS2/V2V use case, within the module's 200-750 VDC range.
- Battery side: nominal 96 V or 108 V battery platform; actual charging voltage and current are commanded according to BMS limits.
- Maximum converter output: 0-200 VDC and 0-80 A, subject to the 7 kW power limit.
- Power flow: assumed to be high-voltage input to lower-voltage battery output. Bidirectional operation is not confirmed by the supplied product sheet.
- CCS2 communications: provided by an external EVCC/PLC subsystem because the supplied module sheet identifies CAN and GB/T 27930, not native CCS2 communication.

2. ATRFD7K-300S96M Specification Summary

Parameter	Supplied Specification	Integration Significance
Product model	ATRFD7K-300S96M	7 kW integrated non-isolated buck charging DC/DC module
Input source	DC charging source	The source must provide regulated high-voltage DC
Rated input voltage	300 VDC	Nominal operating point
Input-voltage range	200-750 VDC	A 200-400 VDC source is electrically within range
Output-voltage range	0-200 VDC	Covers nominal 96 V / 108 V battery charging
Output-current range	0-80 A	At 96 V and 7 kW, current is approximately 72.9 A
Rated output power	7 kW	Current command must also respect the power limit
Typical efficiency	97%	Approximate full-load loss is 210 W at the typical efficiency point
Isolation	Non-isolated	Input and output share a galvanically connected high-voltage domain
Communication	CAN	DBC, timeout behavior and hardware enable must be obtained from the supplier
Supported standard	GB/T 27930	CCS2 requires an external EVCC/PLC and protocol integration
Operating noise	<= 60 dB	Verify test conditions and cooling arrangement

3. Recommended System Architecture

The ATRFD7K-300S96M should be treated as a power-conversion component inside a supervised high-voltage charging system.

CCS2 / V2V DC source 200-750 VDC	F1, KIN+/KIN- KPRE-IN U/I sensing	ATRFD7K-300S96M 7 kW buck DC/DC	F2, KOUT+/KOUT- KPRE-OUT U/I sensing	96/108 V Battery and BMS
→	→	→	→	
EVCC / PLC CP, PP, plug lock ISO 15118 or DIN 70121	Safety ECU HVIL, IMD, contactors, pre-charge and faults	ATRFD7K-300S96M control CAN voltage/current command Hardware enable	Independent protection Fuse coordination, voltage/current plausibility	BMS Voltage/current limits, SOC and stop request

Figure 1. Conceptual system architecture. Component locations and switching sequence must be validated against the supplier's application requirements.

4. Preliminary Contactor, Fuse and Sensor Ratings

4.1 Input Side

At the minimum input voltage, the approximate maximum input current is:

$I_{in,max} = 7000 / (200 \times 0.97) \approx 36.1 \text{ A}$

Item	Preliminary Starting Point	Key Validation
KIN+ and KIN-	>= 800-1000 VDC; continuous current >= 60 A (80-100 A may be selected for margin)	DC breaking capacity, polarity, magnetic blowout direction, bidirectional current capability, coil economy and auxiliary contacts
F1 input fuse	Approximately 50-63 A; voltage rating >= 800-1000 VDC	Coordinate fuse I _t with cable, contactor and semiconductor withstand limits
Input-current sensor	Suggested range: +/- 50 A or +/- 75 A	Accuracy, bandwidth, isolation and plausibility diagnostics
Input-voltage sensor	0-800 VDC minimum; 0-1000 VDC preferred	Creepage, clearance, isolation and independent overvoltage threshold

4.2 Output Side

Approximate full-power output current is 72.9 A at 96 V and 64.8 A at 108 V. Both values are below the module's stated 80 A limit.

Item	Preliminary Starting Point	Key Validation
KOUT+ and KOUT-	>= 250-400 VDC; continuous current >= 100 A (100-150 A may be considered)	DC breaking capacity, fault current, current direction, auxiliary contacts and thermal rise
F2 output fuse	Approximately 100-125 A; voltage rating >= 250 VDC	Coordinate fuse I _t with cable, battery fault current and semiconductor limits
Output-current sensor	Suggested range: +/- 100 A	Bidirectional measurement to detect reverse current
Output-voltage sensor	0-200 VDC minimum; additional margin recommended	Use for pre-charge completion, overvoltage and contactor diagnostics

Selection caution: Continuous-current rating alone is not sufficient. The contactor must also be capable of safely making and breaking the expected DC load and fault conditions. Severe short-circuit current should be cleared primarily by a coordinated high-voltage fuse, not by relying on the contactor alone.

5. Pre-charge Design

5.1 Preferred Method: Active Output-Voltage Matching

If the supplier confirms that the ATRFD7K-300S96M can regulate its output safely with the output contactor open, the converter may be used to match the battery voltage before KOUT+ is closed:

1. Keep KOUT+ open and close KOUT-.

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2. Command zero current, or the supplier's minimum permitted current.
3. Ramp the ATRFD7K-300S96M output voltage toward the measured battery voltage.
4. Confirm that the voltage difference across KOUT+ is within the permitted closing threshold, for example less than 5% or the contactor/module supplier's specified value.
5. Close KOUT+, verify the auxiliary contact and voltage plausibility, then ramp the charging current gradually.

This method may reduce the need for a large output pre-charge resistor, but it is acceptable only after the supplier confirms:

- Stable open-circuit output-voltage regulation.
- Permitted hot connection to the battery after voltage matching.
- Reverse-current blocking behavior.
- Whether battery energy can backfeed into the input when the converter is disabled.
- The internal relationship between Vin-, Vout- and the enclosure.

5.2 Backup Method: Pre-charge Contactor and Resistor

If active voltage matching cannot be verified, install KPRE-OUT and RPRE-OUT in parallel with KOUT+. The following equations provide an initial sizing method:

Purpose	Equation	Notes
Resistance for target time	$R_{pre} = -t / [C \times \ln(1 - \alpha)]$	t = target pre-charge time; C = equivalent bus capacitance; alpha = target voltage ratio
Maximum initial current	$R_{pre} \geq \Delta V / I_{pre,max}$	Select resistance to limit the initial inrush current
Pulse energy	$E = 0.5 \times C \times (\Delta V)^2$	Use the resistor manufacturer's pulse-energy curve, not only continuous wattage
Initial power	$P_{initial} = (\Delta V)^2 / R_{pre}$	Peak power is brief but can be very high

A typical pre-charge completion criterion is one of the following:

- The converter-side bus reaches 90-95% or more of the battery voltage.
- The voltage difference across the main contactor is below 5%, or below the limit specified by the contactor and converter supplier.
- Pre-charge completes within the defined time; otherwise a pre-charge timeout fault is latched.

After successful pre-charge, close the main output contactor, confirm closure by auxiliary contact and voltage measurement, and then open the pre-charge contactor.

5.3 Input-Side Pre-charge

A CCS2 charging station normally controls its output voltage ramp through the charging protocol. A possible sequence is to keep the ATRFD7K-300S96M disabled, close the input contactors, request the EVSE to raise the input bus gradually, verify that the input is within 200-750 VDC, and only then enable the converter. If the module input capacitance or allowable inrush current cannot be handled by the EVSE, add KPRE-IN and RPRE-IN.

Missing data: The actual input and output pre-charge resistor values cannot be calculated from the supplied one-page specification. The supplier must provide the equivalent input capacitance, output capacitance, allowable inrush current and required switching sequence.

6. Insulation Monitoring

Because the ATRFD7K-300S96M is non-isolated, the complete connected circuit should be treated as one floating high-voltage domain. The insulation-monitoring device should measure the resistance from HV+ and HV- to the vehicle chassis.

Requirement	Recommended Design Intent
Voltage coverage	Cover the entire possible domain, preferably 0-1000 VDC, because the input may reach 750 VDC
Compliance basis	Use an automotive-suitable IMD designed for unearthed IT systems; confirm the applicable edition of IEC 61557-8 and vehicle requirements
Diagnostics	Self-test, chassis connection monitoring and a defined failure output
Interface	CAN, PWM or hardwired fault output to the Safety ECU



Requirement	Recommended Design Intent
Thresholds	Provide warning and trip levels; derive thresholds from system voltage, vehicle standard and homologation requirements
Charging-station interaction	Confirm whether the EVSE IMD and vehicle IMD can coexist; avoid measurement interference

Critical safety point: Do not set the insulation threshold only from the 96 V or 108 V battery voltage. When the non-isolated converter is connected, the domain may be exposed to the source voltage, potentially as high as 750 VDC.

7. Recommended Operating Sequence

Stage	Required Actions and Checks
1. Low-voltage startup	Keep all HV contactors open. Run MCU, RAM, Flash and watchdog self-tests. Check voltage/current sensor plausibility, contactor auxiliary contacts, HVIL, emergency stop, crash input, BMS/TR6041/EVCC communications and residual bus voltage.
2. CCS2 connection	Detect plug insertion, evaluate CP/PP, lock the connector, establish EVCC-SECC PLC communication, receive BMS voltage/current limits and perform the required cable and insulation checks.
3. Establish input bus	Keep the ATRFD7K-300S96M disabled. Use EVSE voltage ramping or the input pre-charge branch. Verify input voltage within 200-750 VDC and confirm contactor states.
4. Pre-charge output	Read battery voltage. Close KOUT-. Use active voltage matching or KPRE-OUT/RPRE-OUT. Confirm the output bus is close to battery voltage, close KOUT+, verify closure and open the pre-charge branch.
5. Normal charging	Command current as the minimum of the BMS, ATRFD7K-300S96M 1, EVSE, cable and thermal limits. Ramp current gradually rather than stepping directly to 65-80 A.
6. Normal stop	Ramp current to zero, verify actual current, disable converter PWM, open output contactors, open input contactors, request EVSE shutdown, discharge residual bus voltage and unlock the connector only after safe conditions are confirmed.

$$I_{cmd} = \text{minimum} (I_{BMS}, I_{TR6041}, I_{EVSE}, I_{cable}, I_{thermal})$$

8. Required Fault Protection

Fault	Detection	Recommended Response
Input overvoltage / undervoltage	Independent input-voltage measurement and plausibility check	Disable PWM and request the EVSE to stop; open contactors when current is within safe breaking limits
Output overvoltage	Hardware comparator plus software monitoring	Immediately disable PWM and open the output path using the approved sequence
Output overcurrent / short circuit	Fast current sensing plus coordinated fuse	Use a hardware PWM shutdown path; the HV fuse clears severe fault current
Reverse current	Bidirectional output-current measurement	Disable PWM and isolate the battery if reverse current is not permitted
Pre-charge timeout	Bus voltage fails to reach the threshold within the allowed time	Open pre-charge and main contactors; latch a restart-inhibit fault
Low insulation resistance	IMD warning/trip output	Stop charging and open both input and output HV paths
HVIL open	Independent interlock circuit	Stop power conversion immediately and perform a controlled safe isolation



Fault	Detection	Recommended Response
Contactor welded / failed to close	Auxiliary contact plus voltage measurement across the contactor	Inhibit restart and require service
CAN / PLC timeout	Timeout, alive counter and message plausibility	Ramp current to zero and isolate; use immediate shutdown for severe communication loss
Overtemperature	Module, terminal, cable and inlet temperature sensors	Derate first; stop charging above the trip threshold
Cooling failure	Flow, fan or temperature monitoring as applicable	Derate or stop based on the thermal safety strategy
Sensor fault	Dual-channel or cross-plausibility diagnostics	Prevent HV operation or transition to a defined safe state
MCU failure	Independent watchdog and hardware enable line	Force converter disable and open the contactors through an independent safety path

Protection principle: Short-circuit and severe overcurrent protection must not depend only on a CAN message. Provide an independent hardware route that disables converter switching. Contactors should only interrupt current within their validated DC breaking capability.

9. Controller Responsibilities

Controller	Primary Responsibilities
EVCC / PLC controller	CCS2 CP/PP handling, connector lock, PLC communication, DIN 70121 / ISO 15118 session and EVSE coordination
Safety ECU / VCU	Contactor sequencing, pre-charge, IMD, HVIL, voltage/current plausibility, fault state machine and safe shutdown
ATRFD7K-300S96M controller	Execute CAN voltage/current commands, internal power-stage protection and status reporting
BMS	Battery voltage/current limits, SOC, temperature limits, charge-permission and immediate stop request

The Safety ECU should be capable of disabling the ATRFD7K-300S96M through a hardware enable or emergency-stop path even if CAN communication or the converter software fails.

10. Information Required from the ATRFD7K-300S96M

- Equivalent input capacitance (C_{in}) and output capacitance (C_{out}).
- Internal electrical relationship among V_{in}-, V_{out}- and the enclosure/chassis.
- Reverse-energy behavior when the converter is disabled.
- Presence and rating of reverse-current blocking.
- Whether open-circuit output-voltage regulation is supported.
- Maximum permitted input and output inrush current.
- Required contactor and pre-charge sequence.
- CAN DBC, command update rate, timeout behavior, status and diagnostic definitions.
- Hardware enable, emergency-stop and fault-output pin definitions.
- Short-circuit withstand time, semiconductor I_T and recommended fuse.
- Presence and value of internal discharge resistors.
- Efficiency map and thermal/cooling requirements over voltage, current and ambient temperature.
- EMC, vibration, environmental, reliability and functional-safety evidence.
- Confirmation of single-direction or bidirectional power flow.
- Confirmed compatibility with external IMD measurement and CCS2 system integration.

11. Preliminary Engineering Conclusion

The ATRFD7K-300S96M is electrically suitable as a 7 kW step-down charging power stage for a system receiving 200-400 VDC and charging a nominal 96 V or 108 V battery, provided that the output command is constrained to the battery's BMS-defined charging envelope.



The preferred system concept uses dual-pole contactors on both the input and output sides, a validated output pre-charge method, a coordinated high-voltage fuse on each side, independent voltage and current measurement, an IMD covering the entire non-isolated high-voltage domain, HVIL, EVCC/PLC and a dedicated Safety ECU.

Final approval is conditional on receiving the supplier data listed above and completing DFMEA, fault-injection testing, insulation coordination, thermal validation, EMC testing, contactor/fuse coordination and the required vehicle certification.

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